40 Kilmer, A. (1960) Two New Lists of Key Numbers for Mathematical Operations, *Orientalia* no. 29: 273-308, and consequently, *Reallexicon*, *sub* 'Leier': 573, Musik: 463, and Krispjin, T. (1980) Beitrage zur altorientalische Musikforschung, *Akkadica* no. 70: 6 and 23, note 39.

41 The 'overture' of the *sammūm* = geš-tu-za-mi (which makes no sense for a lyre as there is no opening in its structure), the gold fixtures of the *sammūm* seem to be the gold pegs of the Pu-abi's harp, etc. *Cf.* Gurney, O.R., and Lawergren, B. (1987) Sounds Holes and Geomerical Figures: clues to the terminology of ancient Mesopotamian harps, *Iraq* no. 49: 37-52, and Dumbrill, R. (2005) *The Archaeomusicology of the Ancient Near East.* Trafford. Book 3: 184, 222.

42 This setting fits the theoretical indications of UET VII, 74 for the giš zà.mí = *sammūm*: the indications are given according to a cyclical system of descending fourth (5-2, 1-5, 4-1, 7-4, 3-7, 6-3, 2-6). See Gurney, O.R. (1968) An Old Babylonian treatise on the tuning of the Harp, *Iraq* no. 30: 229-233, and Babylonian Music Again (1994) *Iraq* no. 56: 101-106.

43 Rashid, S.A., *op.cit.*: 53, no. 29.

44 The Ur texts attest that stringed instruments were made from various metals and wood essences (bronze, gold and silver for the soundbox: *sakkullu*-wood, cypress wood, and ma + gunu = pomegranate), Legrain, L., Business documents of the third Dynasty of Ur, *Ur Excavations Texts III* (1974-London): no. 363, 406, 423, 455, 547, 552, 554, 577, 578, 650, 680, 723, 1498.

45 Rashid, S.A. *op.cit.*: 35, 41, 81, 87, 89, 123, n°141, 139.

46 Rashid, S.A. *op.cit.:* 49 : no. 15, 16, 53: no. 30.

47 Barrelet, M.T. *op.cit.*: no. 829. Both Barrelet and Ziegler (*FM IX:* 262-3) identify these objects as weapons.

47a However, Collon, in the present volume: 60, fig. 13a, disagrees with me since she interprets a plectrum when I see a thumb.

48 Parrot, A., *MAM III*: 89-96, 327-8; *MAM IV*: 89-91, 93, no. 68, figs 127 to 131, pl. XLV et XLVI; Les fouilles de Mari-8ème campagne (automne 1952), *Syria* 1953 no. 30: 210, pl. XXIII; *Sumer* 2006: 126-127; *FM IX:* 8, fn. 9. For the ambiguous gender of Ur-nanše, see Spycket, A. (1972) La musique instrumentale mésopotamienne, *Journal des Savants.* Institut de France: 156.

49 Collon, D., *First impressions*: p. 101, no. 453; p. 124, 525.

# Appendix

## *By: Richard Dumbrill*

The bulla from Mari with seal impressions (TH 97-35), the object of Marcetteau's paper, and the remarks made upon its delivery during the ICONEA 2008 conference, have prompted the present analysis of third millennium glyptic reliability. An objection about one of Marcetteau's postulations was that in the piece under discussion, with regard to the two harps depicted, there could be no reliable metrology drawn from them. This appendix will expose that, contrarily to this objection, the care of the lapicide was such that their anaglyphs can provide us with reliable organo-metrologic data.

## Methodology

The method for this study consisted in tracing the stringing plan for both harps. This was taken from an average outline with little error tolerance. The angle of the plan was made from the lines taken from first and last strings at both their extremities. The material arising from the outline was used for comparative analysis of string lengths and angles produced, with sexagesimal string lengths quantification as we know it from the tables of regular numbers in the mathematical texts excavated at the Temple Library of Nippur, ca.2200 B.C. The figures are given as regular numbers, in string-length as well as in frequency ratios and in musical cents.

Fig. 1. These enlargements have been lifted from the photographs taken in situ by Marcetteau. The positioning of the instruments has been modified so that the verticals of the instruments form a $90^0$ angle with the horizon line, for better evaluation.

## Analysis

Firstly, let us examine the morphology of the harps. They belong to the arched monumental monostructural type which had elsewhere been wrongly defined as monoxylous as it is impossible to ascertain if the body of the instruments were made of the same wood throughout and exclusively. It is equally impossible to determine, specifically, any other medium that would have been used for their making. The choice of materials is fairly varied. Hollowed-out wood is a possibility, but they could also have been made of mould-shaped and sun-dried raw hide; of woven vegetal, or mixed vegetal and animal fibres, bonded with bitumen, polished, painted, or otherwise treated to satisfaction. They could also have been gold-, silver-, or copper-plated. Philology provides additional clues. However, this is not relevant to this appendix which is exclusively tonometric.

Now, the argument against the possibility of meaningful organo-metrology rests on the fact that at

*prima facie, res ipsa loquitur:* it is far too small to produce anything reliable. However, my counter-argument is that unreliability is unproven as long as it remains untested and that therefore the following analysis consists in proving that, at least in the case of TH 97-35, the lapicide's accuracy was metrologically reliable.

The outline of the internal angles of the body of the harps have been drawn from an average calculation and produce 111° for harp I and 107° for harp II. This produces a comfortable average of 110° degrees.

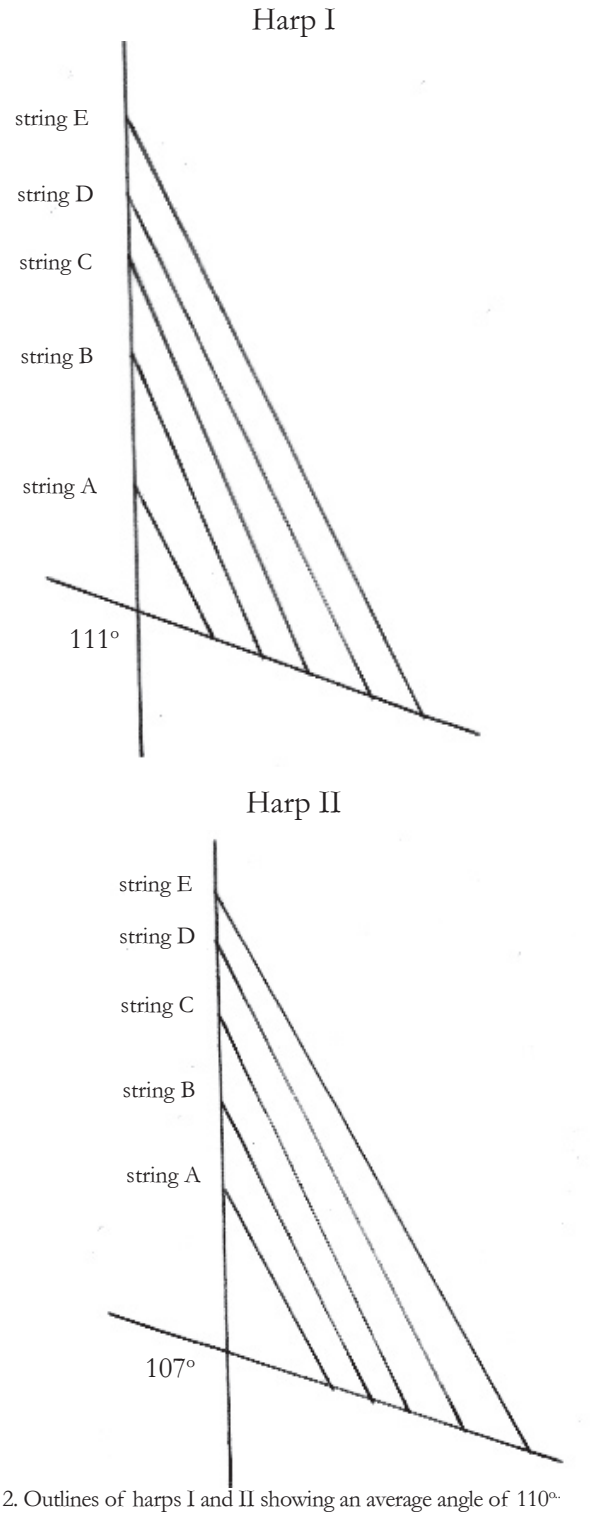



Fig. 2. Outlines of harps I and II showing an average angle of 110°.

The length of the strings are averaged and the figures reduced to fit within the regular numbers up to 80. With both harps, string A is the shortest.

The tables that follow list the five strings, A;B;C;D;E, the column headed 1/1 gives measurements from the photographs; 1/2 is the division of the figures to fit in with the Nippur numbers; the column headed Nippur gives the corrections of the readings to fit with the sexagesimal paradigm. Therefore the tolerance percentage is within the difference between the readings of column 1/2 and column Nippur.

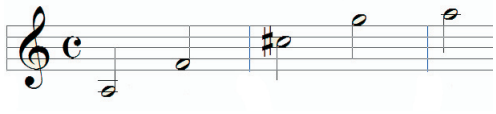
Harp I

| String | 1/1 | 1/2 | Nippur | Note |
|---|---|---|---|---|
| A | 40 | 20 | 20 | A |
| B | 75 | 37 | 36 | G |
| C | 104 | 52 | 50 | $C^{\#}$ |
| D | 126 | 63 | 64 | F |
| E | 153 | 76 | 80 | A |

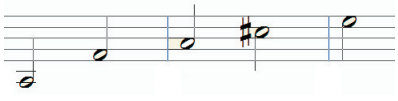
Harp II

| String | 1/1 | 1/2 | Nippur | Note |
|---|---|---|---|---|
| A | 42 | 21 | 20 | A |
| B | 64 | 32 | 32 | F |
| C | 85 | 42 | 40 | A |
| D | 104 | 52 | 50 | $C^{\#}$ |
| E | 124 | 62 | 60 | E |

Harp I

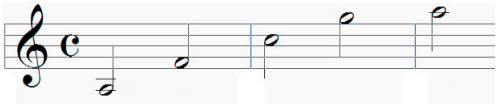


Harp II

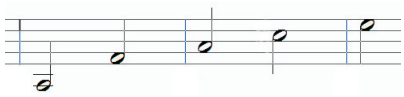


The presence of $C^{\#}$ is incongruous and I would restore it with a natural C which in the Nippur tables is 48 instead of 50. This constitutes a negligeable quantity. This gives:

Harp I



Harp II



Therefore, the correction must be applied to tables for harps I and II in order to define relative pitches and cent values for each of the strings.

Harp I redefined

| String | 1/1 | 1/2 | Nippur | Note |
|---|---|---|---|---|
| A | 40 | 20 | 20 | A |
| B | 75 | 37 | 36 | G |
| C | 104 | 50 | 48 | C |
| D | 126 | 63 | 64 | F |
| E | 153 | 76 | 80 | A |

Harp II redefined

| String | 1/1 | 1/2 | Nippur | Note |
|---|---|---|---|---|
| A | 42 | 21 | 20 | A |
| B | 64 | 32 | 32 | F |
| C | 85 | 42 | 40 | A |
| D | 104 | 50 | 48 | C |
| E | 124 | 62 | 60 | E |

Harp I has the following ratios: 80:64; 64:48; 48:36; and 36:20

80:64 = 386.31 cents = just major third

64:48 = 498.05 cents = just fourth

48:36 = 498.05 cents = just fourth

36:20 = 1017.60 cents = acute minor seventh

Harp II has 60:48; 48:40; 40:32; and 32:20.

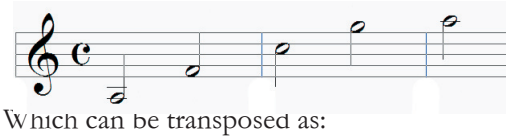
60:48 = 386.31cents = just major third

48:40 = 315.64 cents = just minor third

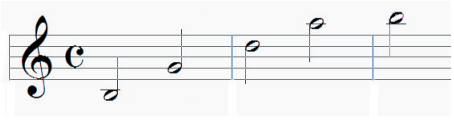
40:32 = 386.31 cents = just major third

32:20 = 813.69 cents = just minor sixth

All of these intervals are just because they come from the sexagesimal Sumerian system. They fit in with the earliest Mesopotamia theory which found its roots in the Sumerian model. For instance, with harp one, we have:



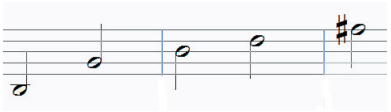
Which can be transposed as:



Note that now the central note is a D from which an ascending and a descending fifth are projected forming the enneachord we find with UET VII, 126.

Note that the extreme notes are distant from their neighbours by a minor sixth. The span of this instrument is the double octave.

If an identical transposition is made with harp II, we have the following:



Here the span is smaller. However, both start from the bass with a just minor sixth. The central D is surrounded by a descending just major third and an ascending just minor third, the central D is a just fifth away from top $f^{\#}$.

We could derive that the central D, in both harps, equates to *ḫanšu* as we have it in *nabnitu* XXXII and other texts.

Should the present experimentation in organo-tonometry be correct, then this would prove that the theory in Nabnitu XXXII was known in the second half of the third millennium, at Mari, if not elesewhere in Mesopotamia.

These monumental angular monostructural harps were the equivalent of our double bass and would have had their strings played in pre-defined repetitive patterns for which we have good paralels in *Gnawa* music in the south of Morocco, although this would be played on the monumental *genbri*. The absence of semitones could be construed as evidence that these instruments were conceived to play in the pentatonic *genus*.

## Testing the results

However satisfactory these figures may be, it still remains to be proved that variations in the angle of the harps would not yield equally satisfactory figures. The results have shown that only a right-angled instrument gave measurements which were even more satisfactory than those produced with the original 110 degrees, but this gave a diatonic system, and the harps from Mari were certainly not tuned diatonically at that time, as we have seen, above. They were pentatonic paradigms. Harp I has 60;50;40;30 and 15 and harp II has 50;40;36;25 and 15. However, other test measurements with 45°, 135° and one other aleatory figure gave measurements of little coherence. Therefore it is reasonably safe to rely on the accuracy of the lapicide.

However, the next problem concerns the technique that was used to reach such accurate levels and for which I am unable to give any satisfactory answer. Would seal makers be given instructions that were so precise that the angles of harps and the number and position of their strings be sufficiently reliable to allow us, millennia later, some serious organo-metrology?